PUBLICATION No. 738
TECHNICAL BULLETIN 44

ISSUED SEPTEMBER, 1942
FIRST PRINTING

AN ECOLOGICAL *and* GRAZING CAPACITY STUDY OF THE NATIVE GRASS PASTURES

IN

SOUTHERN ALBERTA, SASKATCHEWAN AND MANITOBA

by

S. E. CLARKE,
Agricultural Scientist,
in charge of Forage Crops and Pasture Studies.

J. A. CAMPBELL,
Agricultural Supervisor.

J. B. CAMPBELL,
Agricultural Supervisor.

DIVISION OF FORAGE CROPS
Dominion Experimental Station,
Swift Current, Sask.

Published by authority of the Hon. JAMES G. GARDINER, Minister of Agriculture,
Ottawa, Canada

10M—6111-9-42

TABLE OF CONTENTS

AN ECOLOGICAL AND GRAZING CAPACITY STUDY OF THE NATIVE GRASS PASTURE IN SOUTHERN ALBERTA, SASKATCHEWAN AND MANITOBA

INTRODUCTION

In 1937 a survey of the grasslands in Alberta, Saskatchewan and Manitoba was inaugurated as one of the activities of the Prairie Farm Rehabilitation program. The chief purposes of the survey are, to classify the native grasslands according to the botanical composition of the vegetation, to ascertain the carrying capacity of the various grazing districts, and to determine how the native grass pastures should be utilized in order to secure the maximum production of animal products and yet maintain the forage cover. Since the inception of the survey slightly over three million acres have been studied.

The area being surveyed is in the southern portion of the three provinces. The Rocky Mountains, the International Boundary between Canada and the United States, and the Red River are respectively the western, southern and eastern borders of the domain; while a line running northwest from Winnipeg, Manitoba, to Lloydminster, Saskatchewan, and from there southwest to the Rocky Mountains in the vicinity of Banff, Alberta, is the northern boundary (plate 1). The region included within these boundaries contains practically all of the prairies and certain adjacent portions of the "Park Belt". It is estimated that within this tract of country there are nearly thirty million acres of native grassland used for pasture. The larger blocks of grassland are located close to the western and southern borders of the area, while smaller parcels are scattered over the entire region.

The grazing industry in Western Canada had its inception about 1875. From then until about 1900 it developed rapidly. Range was free and grass was abundant. Occasionally the winters were long and cold, but during many years the warm chinook winds kept the pastures partially cleared of snow and the temperatures moderate, thus allowing winter grazing during most seasons. These favourable factors, combined with the apparent possibilities for unlimited expansion induced the movement of capital into the region, first into the Foothill areas and later to the prairies. By 1901 the cattle population of Alberta and Saskatchewan had increased to 590,000 head, while sheep numbered about 153,000.

The period of rapid expansion ended with the advent of dryland farmers about 1900. With the inevitable progress of land settlement the trend in ranching was changed from one of open range methods to one of ranch consolidation. Properties were purchased or leased, fences were constructed, and arable lands cultivated to provide winter feed. From 1900 to 1912 there was a strong local market for horses and cattle created by the demands of the farmer settlers. From 1914 to 1918 the demand induced by the World War maintained ranch revenues.

58438—1½

Conditions changed about 1920, the high prices for live stock disappeared and grazing resources started to show signs of depletion. An over-grazed condition was developing or had developed on many ranges, and live stock populations were greater than the average grazing capacity of the pastures. Sufficient supplies of winter feed were not being maintained to offset the ranch consolidation and more stock-watering sites were needed on many ranches to obtain more efficient land use. Prolonged summer droughts and severe winters added to the burdens of decreased productivity and dwindling revenue, forcing many ranchers to reduce their herds and flocks and others to liquidate their investments. General concern among stockmen concerning the future of the ranching industry prompted them to request the Dominion Government in 1925, to investigate conditions throughout the range areas

In answer to their request an investigation was conducted in 1926, and in the following year the Dominion Range Experiment Station was established near Manyberries, Alberta.

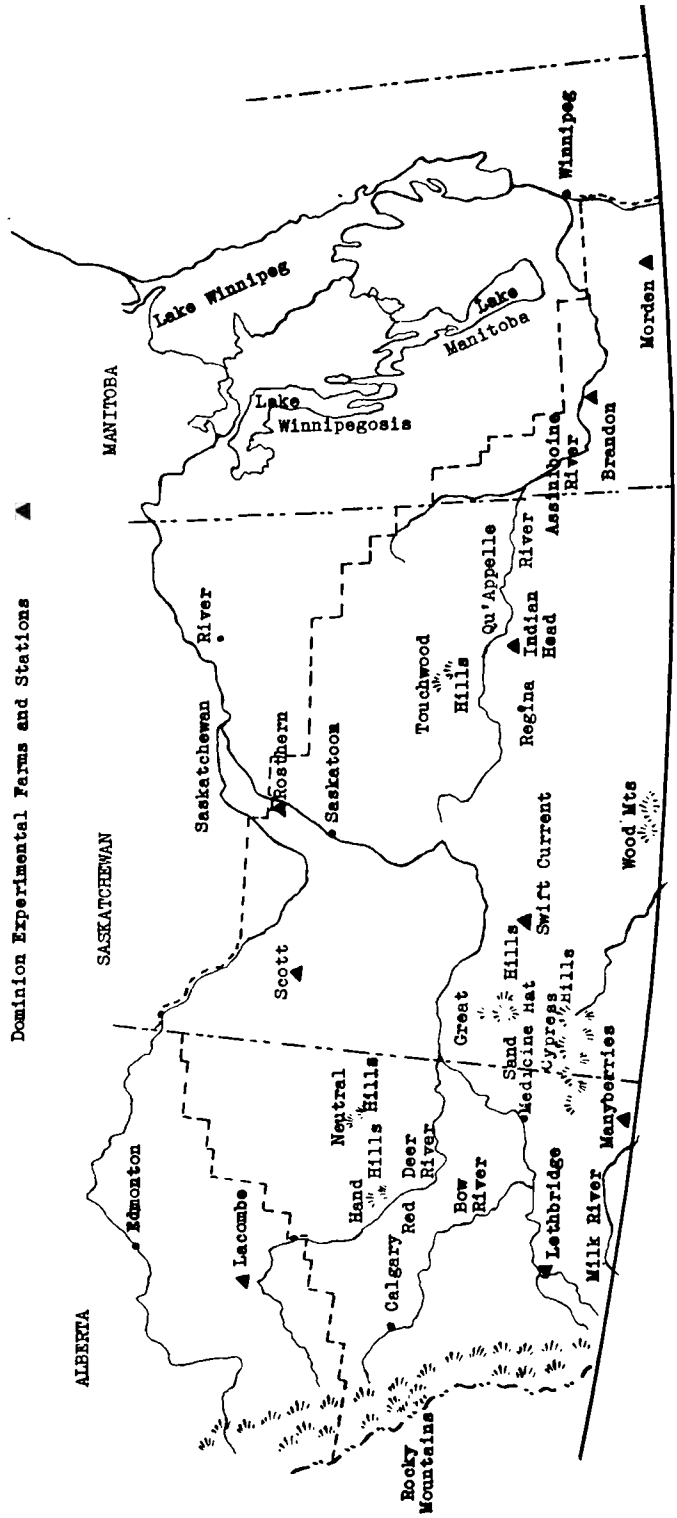
At the Manyberries Station, which is located in the heart of the ranching country, extensive studies were inaugurated concerning range management problems. These studies included, the relative merits of different grazing practices, the carrying capacity of range pastures, the distribution of watering places and salt licks, and the development of small irrigation projects for the purpose of producing winter feed. Detailed studies were made of the vegetational cover of the pastures, including their botanical composition, distribution of plant associations, percentage grass cover, yields of forage species and associations, and the changes brought about by climatic conditions and different grazing practices.

A more favourable period was experienced during the years 1927 to 1929. This was followed, however, by a period of dry years extending to and including 1937, which was the driest season on record. The drought resulted in further depletion of pastures and reduction of live stock. These adverse conditions affected stockmen and grain farmers alike, and in an effort to alleviate the situation the Dominion Government enacted legislation in 1935 known as the Prairie Farm Rehabilitation Act. The Act made provision for a cultural program which includes such projects as soil-drift control and related drought problems, the reclamation of eroded lands, and soil, economic and botanical surveys; a land utilization department whose main activities are the establishment of community pastures and the resettlement of farmers on better-quality and irrigated lands; and a water development branch which administers the construction of irrigation projects, stock-watering dams and dugouts.

The pasture survey was one of the activities provided for under the cultural section of the Act. This study has been conducted on privately-owned ranches, community pastures and special areas throughout the three provinces. Reports on the areas surveyed have been prepared and presented to owners, managers and other interested parties. These reports embody information relating to the vegetational cover, its botanical composition, density and nutritive value; the carrying capacity of the areas studied; and definite recommendations pertaining to the management of the pastures.

This bulletin outlines the nature of the pasture survey studies, and the relationship between these studies and certain physical and biotic factors, such as soil, climate and grazing practices which influence the productivity of the native grasslands.

PLATE 1. IMPORTANT PHYSICAL FEATURES IN SOUTHERN ALBERTA, SASKATCHEWAN AND MANITOBA.



PHYSICAL FACTORS INFLUENCING BOTANICAL COMPOSITION AND YIELD OF THE VEGETATIONAL COVER

Topography, climate and soil are the principal physical factors affecting the productivity of lands throughout the prairie region of Western Canada. These factors ultimately determine which portions shall be brought under cultivation and used for the production of cereal crops, and which shall be left as native sod and used for grazing purposes. They also determine what crops should be produced and the yields that may be expected. A good understanding of these important factors, and of their effects upon agricultural practices and production is essential in determining how the prairie region can be utilized to the greatest advantage.

Topography

The topography of the area under consideration is represented as a plain, the highest portion of which is the district adjacent to the Rocky Mountains. From there the plain extends eastward in a series of steppes until the lowest level is reached along the valley of the Red River in Manitoba.

Some idea of the differences in elevation may be gained by reference to plate 1. Pincher Creek, Calgary and Lethbridge, all close to the western boundary, have altitudes of 3,773, 3,438, and 2,983 feet respectively. Redcliffe, a town near Medicine Hat but not situated in the river valley has an elevation of 2,439 feet above sea level. Continuing eastward through the provinces of Saskatchewan and Manitoba the following altitudes are recorded: Swift Current—2,432, Regina—1,896, Brandon—1,204, and Winnipeg—766.

The continuity of this great plain is broken by several ranges of hills, including the Cypress Hills, Handhills, Neutral Hills, Touchwood Hills and Wood Mountains. These hills rise from 250 to 2,000 feet above the surrounding prairie. Certain other portions are classified as hilly or rolling prairie.

Broad river valleys, from 100 to 500 feet deep are also typical topographical features. These include the North and South Saskatchewan, Bow, Red Deer, Assiniboine, Red, Frenchman and Milk Rivers. The Saskatchewan River, the Red River and their tributaries drain into Lake Winnipeg and Hudson Bay, while the Milk and Frenchman Rivers empty into the Missouri and thus form part of the Mississippi River drainage system.

Roughness of topography renders certain areas unfit for cultivation, but well suited for grazing purposes. Usually more favourable growth conditions are encountered at higher altitudes, precipitation being greater, evaporation less and the soil generally productive. These factors induce the development of heavier-producing forage species, thus increasing the carrying capacity of the lands and making them more desirable for the production of live stock. Although roughness of topography is not always associated with greater carrying capacity, there are other factors connected with rough topography which are advantageous to stockmen. Natural stock-watering places are usually abundant, and sites for the development of other water supplies are usually plentiful. There is also more shelter in these rough areas, an element of importance to graziers. Owing to these favourable factors areas of rough topography provide some of the best range pastures.

Climate

Annual precipitation is the principal climatic factor affecting vegetative growth over the entire prairie area, particularly in the western and southern portions. Not only is it limited in amount, but its distribution is uncertain. Meteorological records indicate that over a period of years about one-half of the annual precipitation occurs during the months April to July inclusive. This, however, is not constant, for as little as one-seventh or as much as four-fifths may fall during the same period in any particular year. In addition, wide yearly variations can be expected. A drop of from 25·28 to 7·64 inches of total precipitation was recorded at Medicine Hat, Alberta, in two successive seasons (1927 and 1928). Other factors including temperature, evaporation and wind velocity add to the complex effects of climate.

Selected meteorological data from representative stations are presented in table 1. With the exception of the Manyberries records which are for an eleven-year period, all records of temperature and precipitation are for twenty-six years or more. The selected stations are close to the southern and northern boundaries of the area covered by the survey. All of the stations listed in the table are shown on plate 1.

TABLE 1.—TEMPERATURE, PRECIPITATION AND EVAPORATION RECORDS FROM SELECTED STATIONS IN THE PRAIRIE PROVINCES

Station	Mean Annual Temp. in ° F.	Average Precipitation		Evaporation in ins.	P:E Ratio	Refer.
		Annual	April to July			
Pincher Creek, Alta..	39	19·52	10·96			1
Lethbridge, Alta ..	41	15·96	9·05	24·96	0·64	2
Medicine Hat, Alta... ..	42	12·75	6·76			1
Manyberries, Alta....	40	10·71	5·36	33·02	0·32	2
Klintonel, Sask.*. ...	36	17·90	8·61			1
Swift Current, Sask	38	13·22	7·04	30·08	0·44	2
Indian Head, Sask.	34	18·32	9·30	21·62	0·85	2
Morden, Man ...	36	19·05	9·92	23·21	0·84	2
Brandon, Man	34	18·84	8·52	16·19	1·16	2
Rosthern, Sask	33	14·62	7·43	19·02	0·77	2
Scott, Sask	32	13·40	7·27	21·76	0·62	2
Lacombe, Alta...	35	17·27	9·67	16·44	1·05	2

* Klintonel is located in the Cypress Hills.
1. Canada Year Book 1930.
2. Dominion Experimental Farm Reports and Records.

$$\frac{\text{Annual precipitation in inches}}{\text{Seasonal evaporation in inches from a free water surface (April to August inclusive)}} = \text{P:E ratio.}$$

The records presented in table 1 indicate that there is an area of low average seasonal and annual precipitation surrounding Medicine Hat and Manyberries. The table further shows that there is a greater average rainfall at stations near the eastern, western and northern margins of the region.

Evaporation records are presented for a five-month season (May to September inclusive). The data indicate that evaporation from a free water surface is greater at Manyberries than at any other point. The precipitation-evaporation ratio is lowest at the same station.

Mean temperature as shown by the records decreases from a high of 42° F. at Medicine Hat to a low of 32° F. at Scott. Although these are the extreme temperatures given in the table, they are representative of fairly large districts

surrounding the two stations. Thus there is a region which has a mean temperature equal or nearly equal to that of Medicine Hat. This area extends westward to the vicinity of Lethbridge, nearly as far east as Swift Current, and northward from the International Boundary to the vicinity of the Red Deer River. The mean temperature at Scott is also representative of temperatures over a considerable area. It will be noted that the mean temperature at Rosthern is only one degree higher.

A broad picture of the climate within the region would show, first, that there is a district surrounding Medicine Hat which has a low annual precipitation, a high evaporation rate and a high mean temperature, and second, that rainfall increases, while mean temperatures and evaporation rates decrease toward the northern and eastern margins. As stated previously rainfall is the chief climatic factor influencing crop production, but its effects are modified by those of mean temperature, the seasonal distribution of rainfall, the evaporation rate and other climatic factors of less importance.

Soil

The soils of the region are classified into three major divisions, the brown, dark brown and black soil zones,[1] (plate 2). Within each zone the soil varies considerably in texture, large tracts are composed of sand, while others equally large are deposits of glacial lake clay. However, most of the soils are classified as loams which vary from sandy types to those which are composed mostly of clay. These soils are derived largely from glacial deposits, although sedentary types are found in the Foothills and Cypress Hills.

Soils in the brown soil zone have developed under the lowest rainfall in the area. They have brown or greyish-brown surface horizons which are lower in organic matter than the corresponding horizons of the other zones. The lime layer, or layer of calcium carbonate accumulation, is encountered generally at from 6 to 14 inches below the surface. In the western portion of the zone the vegetation is dominated by species which characterize the short-grass prairie, while in the eastern portion the dominant species are those of the mixed prairie association.

Surface horizons in the dark brown soil zone are dark brown in colour. They contain greater quantities of organic matter than do similar horizons of the brown soil zone. Lime layers are deeper, varying from 10 to 18 inches below the surface. The vegetation is dominated by species which distinguish the mixed prairie association, although at the outer margin stands of submontane mixed prairie are encountered.

Soils of the black soil zone have surface horizons which are black or nearly so in colour. They contain more nitrogen and organic matter than do the same horizons in the brown and dark brown zones (table 2). The lime layer is generally more than 18 inches, and is often as much as 30 inches below the surface. While these soils have developed under grass vegetation, there has been a considerable invasion of deciduous trees from the grey forest soils located north of the black soil zone.

The chemical compositon of surface soils in the three zones is presented in table 2. Data are taken from the Saskatchewan Soils Survey Report No. 10 (12), and are fairly representative of the soils throughout the area.

[1] The three soil zones, brown, dark brown and black are comparable to the brown, chestnut and chernozem zonal soils of the United States.

TABLE 2.—CHEMICAL COMPOSITION OF TYPICAL BROWN, DARK BROWN AND BLACK SOILS

Soil Zone and Series	Type	Nitrogen %	Phosphorus %	Calcium %
Brown Soil Zone				
Sceptre Series	Heavy clay	0·22	0·06	1·03
Haverhill Series	Loam	0 20	0·05	0·44
Hatton Series	Fine sandy loam	0·16	0·04	0·37
Dark Brown Soil Zone				
Regina Series	Heavy clay	0·27	0·07	1·30
Weyburn Series	Loam	0·26	0·07	0·65
Asquith Series	Fine sandy loam	0·19	0 05	0·70
Black Soil Zone				
Indian Head Series	Heavy clay	0·40	0·09	1·49
Oxbow Series	Loam	0·45	0·06	0·94
Meota Series	Fine sandy loam	0·30	0·04	0·81

VEGETATION

The vegetational cover over most of the area with which the survey is concerned is a grassland climax (plate 2). The exceptions are regions along the northern and western boundaries, and at certain higher altitudes in the interior, where the vegetation is dominated by shrubs and trees. However, the lands which produce the forest associations are not of great importance to the live stock industry, as they provide a very small percentage of the forage produced.

The species which constitute the cover are being collected. To date over 1,100 species have been gathered and placed in the herbarium at the Dominion Experimental Station, Swift Current, Saskatchewan. These species are representative of 426 genera and 112 families. The families having the largest representation being *Poaceae, Cyperaceae, Chenopodiaceae, Carduaceae, Fabaceae, Rosaceae* and *Brassicaceae.*

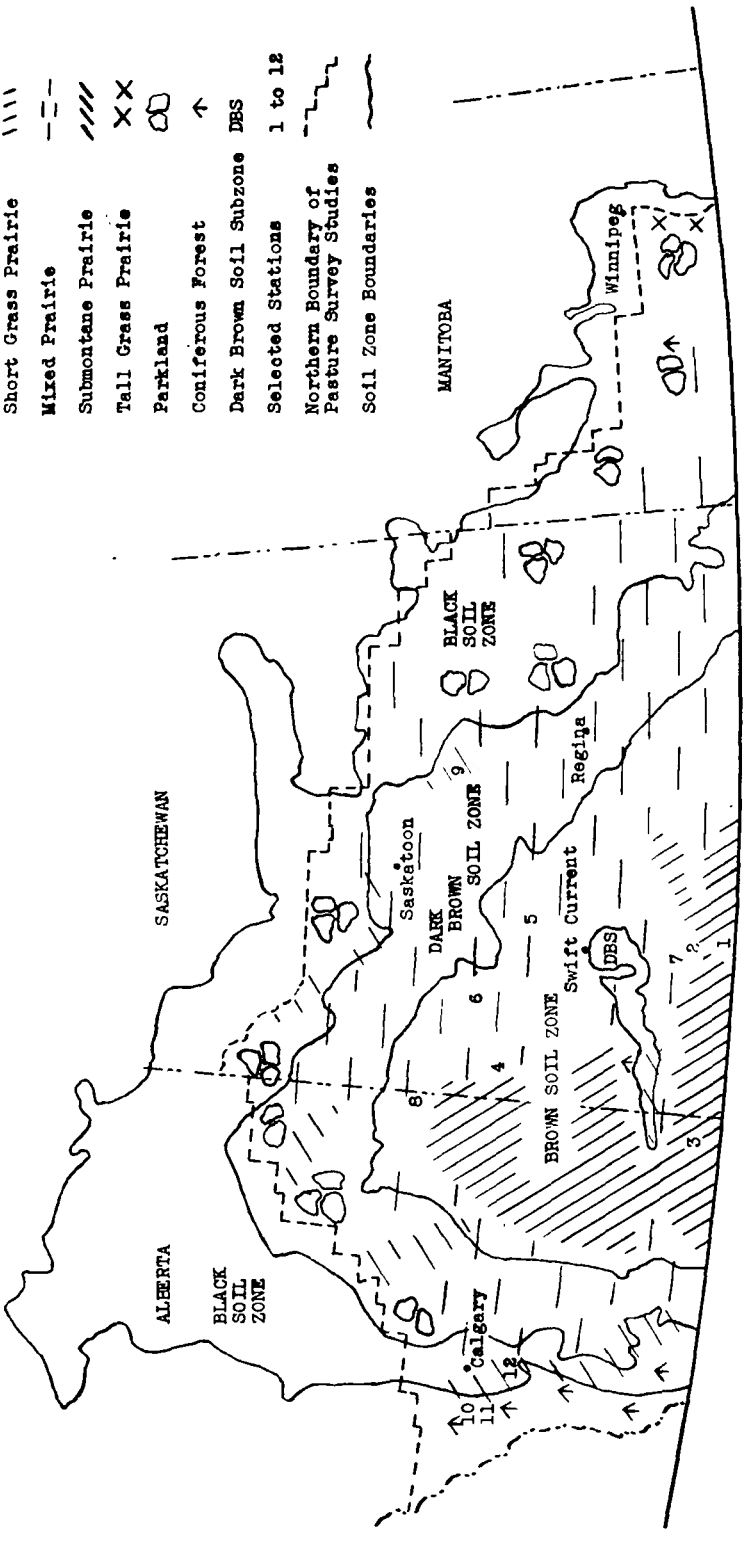
Three main types are recognized within the grassland climax (16).[2] These are classified as follows:

1. Short-grass prairie —Bouteloua-Stipa association.
2. Mixed prairie—Stipa-Agropyron-Bouteloua association.
3. Submontane mixed prairie Festuca-Danthonia association (5).

Forest formations dominate the vegetation in certain areas. Within the wooded portions of the Foothills and Cypress Hills the vegetational cover is characterized by a lodge-pole pine *Pinus contorta latifolia* Wat. sub-climax. Along the northern boundary of the area a gradual change from grassland to forest is noted. This ecotone is generally referred to as Parkland. The grasses are still dominant but slightly improved climatic conditions favour the growth of aspen and willow (10). Further north, and beyond the region covered by the survey, the Parkland gives way to coniferous forest, in which the distinguishing species are jack pine, *P. Banksiana* Lamb., and white spruce, *Picea glauca* (Moench) Voss.

[2] In addition to the three principal grassland types, small areas in southern Manitoba are classified as tall-grass prairie. There are vegetational cover is dominated by big bluestem *Andropogon furcatus* Muhl., Indian grass *Sorghastrum nutan.* (L.) Nash, and prairie cordgrass *Spartina pectinata* Link.

PLATE 2. GENERALIZED MAP OF SOIL ZONES AND VEGETATIONAL ASSOCIATIONS.



Short-Grass Prairie (Bouteloua-Stipa Association)

The short-grass prairie has developed in areas which have a low annual and seasonal rainfall, and where evaporation rates and mean temperatures are relatively high. These conditions, and consequently the short-grass prairie association, are encountered in the southeastern portion of the province of Alberta, along the southern boundary to the vicinity of the Wood Mountains and north of the Cypress Hills as far eastward as the Great Sand Hills in Saskatchewan, and in small isolated areas throughout the mixed prairie region of both provinces (plate 2).

The dominant species is blue grama grass *Bouteloua gracilis* (H.B.K.) Lag., which usually accounts for from one-quarter to two-thirds of the basal grass coverage. It grows in association with variable amounts of other grass species, which may be relatively sparse or nearly as abundant as itself. These include common speargrass *Stipa comata* Trin. & Rup., bluejoint or western wheatgrass *Agropyron Smithii* Rydb., Junegrass *Koeleria cristata* Pers., and Sandberg's bluegrass *Poa secunda* Presl. Three members of the sedge family, involute leaved sedge *Carex Eleocharis* Bailey, thread leaved sedge *C. filifolia* Nutt. and spike rush *Eleocharis palustris* (L.) R. & S. add to the cover. The first is ubiquitous in its habit, the second grows best on lands with sandy loam or eroded soil, the third in moist, often saline sloughs. There are in addition several sub-dominants, both grasses and sedges, which may be present or absent depending on growth conditions at any particular point.

Plant growth generally is shorter in the short-grass prairie region than within the other grassland associations. Not only are the dominant species naturally low growing, but they grow shorter than under more humid conditions. Thus bluejoint, which rarely grows more than from 12 to 18 inches tall in the short-grass region often attains a height of three feet in the mixed prairie area. Likewise, the culms of Junegrass will be about one foot in height, whereas in the submontane mixed prairie they are usually more than two feet tall.

In addition to having characteristic grasses, the short-grass prairie region also produces other herbs as well as shrubs. Amongst these, moss phlox *Phlox*

FIGURE 1.—Short-grass prairie vegetation. Growth has been insufficient to cover the frame. This illustrates the general dwarfed nature of the cover. The shrubs in the background are hoary sagebush.

58438—2½

Hoodii Richards, prickly pear cactus *Opuntia polyacantha* Haw., pasture sage *Artemisia frigida* Willd., broomweed *Gutierrezia diversifolia* Greene, and golden aster *Chrysopsis villosa* (Pursh) Nutt., are the most common. Those of less abundance include hoary sagebush *Artemisia cana* Pursh, prairie sage *A. gnaphalodes* Nutt., silver sage *Eurotia lanata* (Pursh) Moq., and Nuttall's atriplex *Atriplex Nuttallii* S. Wats. Dense covers of little clubmoss *Selaginella densa* Rydb., are associated with this type, 50 per cent stands being not uncommon. Many of these species are valuable forage plants which add to the total yield wherever they occur, the most palatable being silver sage, hoary sagebush and Nuttall's atriplex.

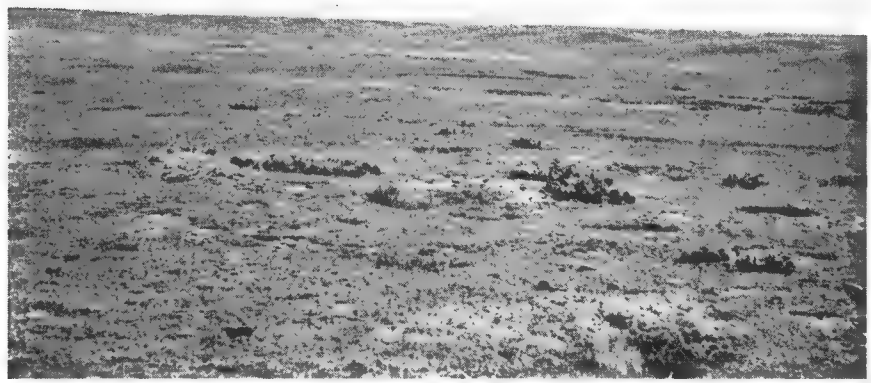


FIGURE 2.—Short-grass prairie vegetation. This land has been overgrazed as indicated by the abundance of prickly pear cactus, and by the eroded condition of the surface soil. Dominant grass species is blue grama grass.

Experience has demonstrated that the production of cereal crops by dry farming practices is a precarious industry in the short-grass prairie region. During very favourable seasons heavy crops are harvested, but during average and poorer than average years returns rarely meet production costs. While not being suitable for the production of cereal crops these areas provide excellent pasture as the native grasses are palatable and nutritious, and live stock feeding on them make rapid and economical gains. Consequently it is recognized that most of the land occupied by short-grass prairie is suitable for pasturage only and should be used accordingly. The presence of many sites where small irrigation projects can be developed, increases the value of these lands for live stock production.

Mixed Prairie (Stipa-Agropyron-Bouteloua Association)

The species which identify the mixed prairie consist of both short and medium-tall grasses, and from this character the association derives its name. The type develops on lands adjacent to the short-grass region, and between this central arid area and the more humid sections to the west, north and east. The structure of the vegetational cover indicates that growth conditions are better than in the short-grass region. This observation is substantiated by meteorological records (table 1).

Practically all of the grasses which occur in the short-grass prairie are also present in the mixed prairie association, although occurring in different proportion (table 9). However, there are several which are not present in the short-grass region that are constituents of mixed prairie. These include

FIGURE 3.—Mixed prairie, Agropyron consociation. The sparse stand of grass in the mid-ground is the result of soil drifting from cultivated land beyond the road. Stands of this type yield from 500 to 750 pounds per acre per year.

FIGURE 4.—Mixed prairie. Stipa-Agropyron faciation. This is an average cover. Note the large proportion of bare ground.

short-awned porcupine grass *Stipa spartes* var *curtiseta* Hitchc., northern wheatgrass *Agropyron desystachyum* (Hook.) Scribn., awned wheatgrass *A. subsecundum* (Link) Hitchc., rough fescue *Festuca scabrella* Torr., sandgrass *Calamovilfa longifolia* (Hook.) Scribn., skyline bluegrass *Poa Cusickii* Vasey, little bluestem *Andropogon scoparius* Michx., and green needle grass *Stipa viridula* Trin.

Members of the Cyperaceae are relatively common. On upland sites involute leaved sedge and sun loving sedge *Carex heliophila* Mack. are the most abundant. In low lying locations awned sedge *C. atherodes* Spreng., and *C. rostrata* Stokes are encountered. Baltic rush *Juncus ater* Rydb., is a constituent of the cover on moist sandy uplands and around sloughs.

FIGURE 5.—Mixed prairie. Stipa-Calamovilfa faciation. Speargrass and sandgrass on knoll in foreground. Shrubs at centre are willows and river birch. Chokecherry dominates the cover on the dunes in the background.

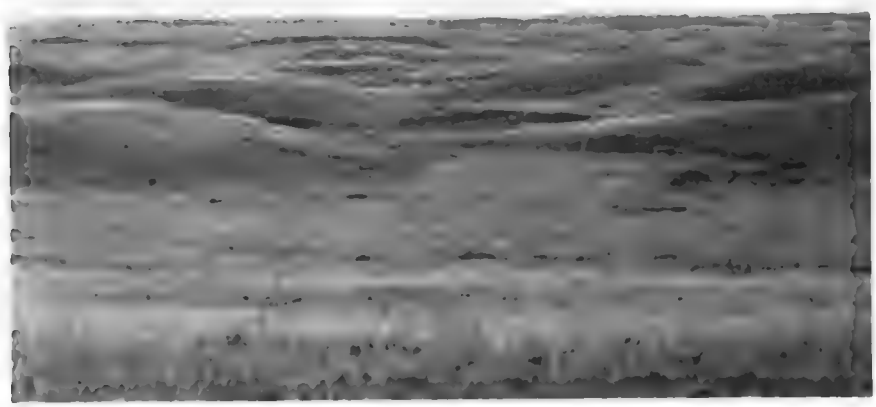


FIGURE 6.—Mixed prairie. Stipa-Bouteloua faciation. Much of the pasture land within the mixed prairie region has topography comparable to that shown. Cattle in background are clustered around a watering-site. This stand will yield about 400 pounds to the acre.

Other herbs and shrubs are relatively abundant, while trees become increasingly important in those portions adjacent to the forest formation. Amongst those of widest distribution are roses *Rosa* spp., western snowberry *Symphoricarpos occidentalis* Hook., wolf willow *Elaeagnus commutata* Bernh., wild licorice *Glycyrrhiza lepidota* Nutt., willows *Salix* spp., and trembling poplar or aspen *Populus tremuloides* Michx. Many of those found in the short-grass prairie are also constituents of the mixed prairie, such species as pasture sage, broomweed, silver sage, Nuttall's atriplex, hoary sagebush, moss phlox and golden aster are present, and may be either rare or abundant. Little clubmoss is usually present, but the covers are not so dense as those in the drier central portion.

Within the confines of the mixed prairie there are several plant communities, each dominated by one or more of the dominants of the association and each expressing variations in the summation of growth factors within the association. A few of the important of these are, (1) the speargrass—blue grama grass faciation which develops on sandy loam soils, (2) the speargrass—wheatgrass faciation which grows on clay loams, (3) the bluejoint consociation (figure 3) which is produced on heavy clay soils, and (4) the speargrass—sandgrass type which dominates on sand soils. Dryland farming for the production of cereals is practised successfully on lands producing the bluejoint and speargrass-wheatgrass communities, but where the speargrass-blue grama grass faciation is dominant dryland farming is seldom successful. On lands where the speargrass-sandgrass type dominates grazing is the only use which can be made of the area, as the soil is composed largely of sand and the topography is often of dune formation (figure 5). Where these species characterize the vegetational cover there is usually a large representation of shrubs including roses, wolf willow, aspen, chokecherry *Prunus melanocarpa* (A. Nels.) Rydb., river birch *Betula fontinalis* Sarg., and creeping cedar *Sabina horizontalis* (Moench) Rydb. There are certain alkaline areas which are suitable for grazing only, where such species as alkali grass *Distichlis stricta* (Torr.) Rydb., Nuttall's alkali grass *Puccinellia Nuttalliana* (Schultes) Hitchc., and cordgrass *Spartina pectinata* Trin., are growing the land cannot be farmed successfully by dryland practice.

Submontane Mixed Prairie (Festuca-Danthonia Association)

This grassland type dominates the vegetation in submontane regions immediately below the lodge-pole pine forests, and in certain areas near the outer margin of the mixed prairie (plate 2). Thus its expression is both altitudinal and latitudinal, depending on a slightly higher rainfall, a lower mean temperature and a lower evaporation rate for its development than the adjacent mixed prairie.

Rough fescue is the dominant grass species. Others of importance are Junegrass, awned wheatgrass, Parry's oatgrass *Danthonia Parryi* Scribn., wild oatgrass *D. intermedia* Vasey, and Idaho fescue *Festuca idahoensis* Elmer. Grasses which are usually present but seldom abundant are bluejoint, short-awned porcupine grass, nodding wild rye *Elymus canadensis* L., and marsh reed-grass *Calamagrostis canadensis* (Michx.) Beauv. Blue grama grass is not present and common speargrass is found only occasionally. The association is further characterized by the presence and often abundance of shrubby cinquefoil *Dasiphora fruticosa* (L.) Rydb. Aspen, roses and willows are particularly abundant along coulees and northern slopes. American hedysarum *Hedysarum americanum* (Michx.) Britton is a common forb. Pines are encountered in the ecotone between the grassland and the forest.

This association develops on diverse soil types within the dark brown and black soil zones. The better quality lands, including level parcels with loam and clay loam soils are cultivated, cereals and forage being the principal crops. Where the lands are of poorer quality, and the regions of rough topography, the raising of live stock is the principal industry

METHODS EMPLOYED IN A STUDY OF THE VEGETATION AND IN THE DETERMINATION OF CARRYING CAPACITY

A study of range pastures in Western Canada was initiated at the Dominion Range Experimental Station, Manyberries, Alberta, in the summer of 1927. A comprehensive program of range research was started in the following year. The chief purpose of these studies was the acquiring of accurate information concerning the native vegetation cover and the determination of the principles underlying proper management and utilization of native grass pastures (4).

FIGURE 7.—Submontane mixed prairie, Festuca-Danthonia faciation. The field in which this picture was taken had been grazed, but the grazing season had ended. The rancher who used this land maintained a carryover comparable to that shown in the plate, feeling that such was necessary to maintain his pastures. Estimated carryover was 50 per cent.

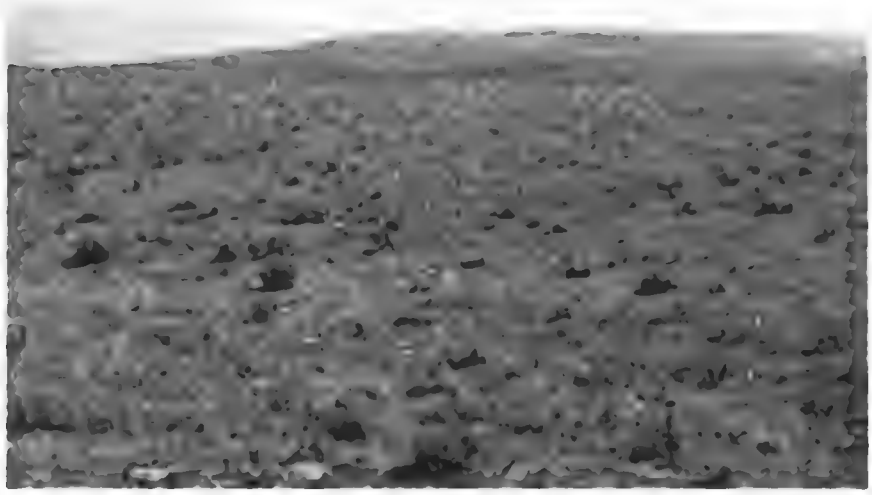


FIGURE 8.—Submontane prairie. Overgrazing has resulted in the disappearance of rough fescue, the spread of shrubby cinquefoil, and extensive erosion on hills in the background. A sufficient carryover would have prevented this condition developing.

The fundamental plant studies included the identification of all native species, a study of the vegetative characters, (2), growth development, palatability, nutritive value, and productive capacity of each of the principal species. Studies of plant communities included determination of the botanical composition, distribution, productivity, and successional relationships of the principal vegetational types.

The botanical composition, density, and productivity of the plant cover was studied chiefly by means of quadrats, perquadrats, transects, exclosures and clipped plots (1) (3).

In range management projects a study was made of the effects of different methods and intensities of grazing upon the botanical composition and productivity of various types of native pasture. The effects of complete protection from grazing were studied in exclosures located in representative parts of each pasture. In these studies use was made of a great number of plots clipped at different intensities and at different times throughout the year.

Projects concerned with the management of live stock on range pastures included studies of the response of range cattle to different methods and intensities of grazing, the gains in weight made by different classes and ages of cattle (6) and the relation of summer grazing to winter maintenance (14). Other projects included the development of stock-watering places, the use of run-off water for irrigation purposes, the distribution of salt licks and the preservation of fence posts.

When grassland surveys were initiated in other portions of the western provinces in 1937, suitable methods of study already had been developed and much fundamental knowledge concerning the nature of the vegetative cover, its management and utilization was available. Furthermore, workers trained in grassland research and acquainted with ranching problems were available for the work.

Pasture Survey Procedure

There are three principal divisions of work in the pasture surveys being conducted. A preliminary survey is made to become acquainted with the area. At this time maps are prepared showing the location of fences, buildings, watering-sites, and physical features. The boundaries of the vegetational communities are also determined and are plotted on the map. The principal plant species are listed and observations are made regarding other features of the vegetational cover.

More detailed studies follow the preliminary survey. These are conducted on each section of land, or where necessary on portions of each section. All plant species are listed, and the location and extent of stands of poisonous plants are mapped. Stock-watering facilities are inspected, and sites are noted where further supplies could be developed. All factors studied during the preliminary survey are dealt with in greater detail.

The principal detailed study concerns the determination of the botanical composition and density of the vegetational cover, and the intensity to which it has been grazed. This is secured by sampling the vegetation at regular intervals across the unit area being studied. The results obtained are recorded on data sheets. (Tables 6 and 7).

After the field work is completed a report is prepared discussing the findings of the survey. This report presents such information as the composition of the vegetational cover and its average yielding ability, the carrying capacity of the area, a discussion of the factors which influence productivity and recommendations regarding pasture management. Copies of these reports are sent to those who administer or manage the pastures concerned.

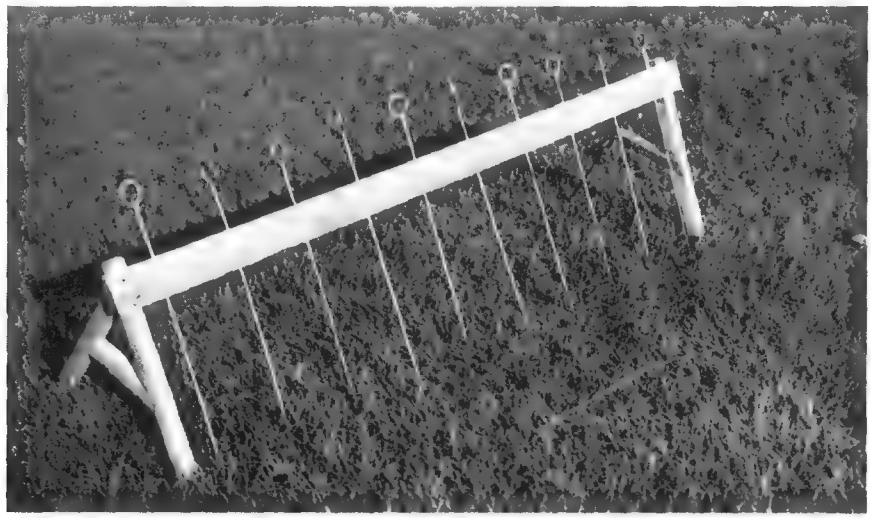


FIGURE 9.—Instrument used to determine the composition of the vegetational cover by the point method.

Methods of Sampling

During the years 1937 to 1939 the area list method was used to sample the vegetation. While this method has been used successfully for certain grassland studies, particularly for detailed investigations on permanent plots, it was found to be less satisfactory for survey work. Consequently in 1939 a study was made of other methods in an effort to choose one which would be equally accurate, yet could be employed more readily in such survey studies. The one selected as being of greatest promise was that one known as the point method (9). This method has been used during the summers of 1940 and 1941, and was found to be satisfactory on the grassland associations involved in the survey.

The point method consists of taking a number of points at random, and in recording the vegetation which is hit as a pin is projected into the sward from above. The apparatus used is a wooden beam mounted on supports and carrying 10 metal pins so held that they slide up and down in a set course. Thus the apparatus plots a broken line transect of 10 points (Fig. 9).

A plant is hit when the point of a pin touches its base. Hits for each species are recorded, and are expressed in terms of percentage of total number of points studied. Thus three hits on bluejoint and 25 hits on little clubmoss per hundred points tested would be recorded as a 3 per cent and 25 per cent cover respectively for each species.

A completed field data sheet is shown in tables 6 and 7. All of the species hit by the pins are listed, and a record is kept of the number of hits on each. This data sheet is designed to show the number of hits on plants per 200 points tested. The average percentage cover of each species, and the total percentage cover of grasses, forbs, weeds and mosses are recorded in the appropriate rows and columns.

Sampling Technique

The technique of sampling by the point method has been studied. Levy (8) reports that 100 points are sufficient to chart a pasture sward when only the dominant species are required. He also points out that from 400 to 500 points are necessary to record those species which are less abundant. The studies conducted on pastures in the Prairie Provinces indicate that no average figure can be used as a measure of the number of samples required, because certain vegetational associations and covers require more intensive sampling than others.

Under the conditions encountered, from 400 to 1,500 points need to be examined to determine the dominant species and their relative proportions. However, when it is also necessary to determine the cover of the less abundant species, from 2,400 to 4,000 points should be tested. These figures have been obtained by calculating the standard error of the mean[1], and reducing it to less than 10 per cent of the mean for the first condition, and to less than 5 per cent when more detailed information is needed.[2]

The number of samples required to determine the botanical composition of the vegetation is apparently a function of the grass cover. Where the vegetation is sparse more samples are required than where it is dense. Analyses show that in an area where the cover is about 5 per cent, some 3,600 points should be tested, but where it is 18 per cent only 2,400 points need be examined. Certain information pertaining to the intensity of sampling is presented in table 3. Although the data presented do not cover the entire range of grass covers which may be encountered, they do show the requirements over a limited range. They also suggest that with a more sparse cover even more point samples should be taken, and conversely, still fewer points need to be tested in areas where the grass cover is of greater density.

Determination of Carrying Capacity

The system used to determine carring capacity is designated as the point-yield method. In using this method it is necessary to determine the basal cover and the floristic composition of the vegetation as described in previous sections; to determine the yielding capacity of the various forage species present; to presume that only 55 per cent of the forage produced by the important forage plants will be utilized; and to presume that a 1,000-pound beef type cow required about 660 pounds of fodder per month (dry-weight basis).

Yields of forage species are secured by clipping and measuring the basal areas of a large number of plants of each species. These clippings are bulked for drying and weighing, and the dry weight of the sample is secured. The basal areas of the plants clipped are summated to obtain the area harvested. The weight of the herbage is divided by the area harvested to secure the yield per unit area for each species. With further calculation this can be expressed in terms of pounds of forage per acre in solid or 100 per cent density stands.

TABLE 3.—NUMBER OF POINTS REQUIRED TO SAMPLE THE VEGETATION BY THE POINT METHOD, IN ORDER TO REDUCE THE STANDARD ERROR OF THE MEAN TO LESS THAN TEN AND FIVE PER CENT OF THE MEAN

Grass Cover in Percentage	Number of Points to be Tested		Grass Cover in Percentage	Number of Points to be Tested	
	10% Error	5% Error		10% Error	5% Error
4·8	1,500	3,600	11·0	700	3,000
6·7	1,200	3,600	12·0	600	2,800
8·4	1,000	3,200	14·0	500	2,600
8·8	900	3,200	14·5	500	2,600
9·3	800	3,000	16·0	600	2,800
10·5	750	3,000	18·0	400	2,400

[1] The standard error of the mean is secured by using the formula

$$S_{\bar{x}} = \sqrt{\frac{\epsilon (x-\bar{x})^2}{\sqrt{N}}} \text{ or } \frac{S}{\sqrt{N}} \text{ (13).}$$

[2] To reduce the standard error of the mean to one per cent of the mean, sampling has to be continued until approximately 80,000 points have been tested.

One hundred per cent density yields of several important forage species are presented in table 4. These data have been gathered over a period of years and under a variety of conditions, both at the Manyberries Experiment Station and by those engaged in pasture surveys.

One of the most important principles basic to the maintenance of native grass pastures is to ensure a carryover of grass from one year to another. If all of the forage is utilized every season, pastures gradually deteriorate, weeds become plentiful and the yields of grass and beef decline. Conversely, if the forage is under-utilized, smaller yields of animal products are obtained, and, furthermore, the grazier loses much valuable feed. Consequently it is necessary to know what portion of the forage can be used by live stock and still maintain the stand. Studies conducted for this purpose indicate that pastures are being properly grazed when about 55 per cent of the annual growth of the principal forage species is utilized.[1]

According to Morrison's Feeding Standards for Farm Animals (11) a 1,000-pound beef cow requires from 19 to 26, and averages about 22 pounds of dry matter daily. Results obtained from experiments conducted at the Dominion Range Experiment Station, Manyberries, Alberta, (6) agree with Morrison's figures. This amount of feed will maintain the animal and also supply sufficient food to produce an average gain of about one and one-half pounds per day in growing beef animals. Thus for a period of one month a 1,000-pound grazing beef cow will require 22 x 30 = 660 pounds of feed. Other classes of live stock will need more or less depending on their age, class and weight (7).

The various steps taken to calculate carrying capacity by the point-yield method are presented in a brief summary. Vegetational covers are measured by the point method. These are multiplied by yield indices to secure the yield of forage per acre. To allow for a carryover, only 55 per cent of the total yield is used in calculation. This is referred to as available forage. The number of acres required to feed a 1,000-pound cow for a period of one month is secured by dividing 660 by the yield of available forage per acre. The procedure for calculation is illustrated in table 5.

TABLE 4.—YIELD IN POUNDS PER ACRE OF 12 NATIVE AND INTRODUCED SPECIES IN 100 PER CENT DENSITY STANDS (DRY-WEIGHT BASIS)

Plant Species	Average Yield in lb. per acre in 100% Density Stands	Relative Productivity Speargrass = 1
Speargrass	5,000	1·0
Bluejoint	6,400	1·28
Junegrass	4,850	0·97
Sandberg's Bluegrass	3,000	0·60
Blue Grama Grass	1,650	0·33
Rough Fescue	9,700	1·94
Parry's Oatgrass	5,000	1·0
Awnless Brome (A)	8,200	1·64
Crested Wheatgrass (B)	12,700	2·54
Thread-leaved Sedge	4,000	0·80
Winterfat	7,400	1·48
Nuttall's Atriplex	11,650	2·33

[1] This figure, 55 per cent, approximates and is used in a similar sense to palatability ratings (15). Work is being continued on this study to secure utilization ratings for all plant species

(A) *Bromus inermis* Leyss. (B) *Agropyron cristatum* (L.) Beauv.

TABLE 5.—CALCULATION OF CARRYING CAPACITY

Plant Species	Ground Cover in Percentage	100% Density Yields	Forage Yield in lb. per acre
Blue Grama Grass	5·5	1650	90·75
Speargrass	1·0	5000	50·0
Bluejoint	1·5	6400	96·0
Junegrass	1·5	4850	72·75
Sandberg's Bluegrass	1·5	3000	45·0
Total Yield of Forage in pounds per acre			354·50

Available forage=354·50 x 55/100=195 pounds.
Carrying Capacity=660/195=3·38 acres per cow-month.

TABLE 6.—PAGE 1, FIELD DATA SHEET.

DOMINION EXPERIMENTAL STATION, SWIFT CURRENT, SASK.

PASTURE SURVEY STUDIES, 1941

Project *LONETREE R.M. 18.* Sec. *26* Tp. *1* Rge. *17* W. *3* Mer.

	Physical Features			Land Utilization				
	Topography	Soil Type	Water Development	Sod	Cult.	Abandoned Reg.	Abandoned Res.	Water
NW	*Gently to*	*Echo Clay Loam*	*Nil*	NW *160*				
	Moderately	*and Haverhill*		NE *90*		*70*		
	Rolling	*Loam (Mixed).*		SE *160*				
NE	"	"	"	SW *160*				
							Regrassed	
SE	"	"	*Site*				*Sod*	
			for a Dam.					
SW	"	"	*Nil*					

ABANDONED LANDS

Quarter	Phase of Succession	Method of Rehabilitation
NW		
NE	*Bluejoint, Pasture Sage.*	
SE		
SW		

CONDITION OF PASTURE

Quarter	Degree of Utilization						Vigor of Growth				Seed Setting		
NW	0	1	2	3	(4)	5	0	1	(2)	3	0	(1)	2
NE	0	1	2	3	(4)	5	0	1	(2)	3	0	(1)	2
SE	0	1	2	3	(4)	5	0	1	(2)	3	0	(1)	2
SW	0	1	2	3	(4)	5	0	1	(2)	3	0	(1)	2

GENERAL NOTES

Section is in good condition. No increase can be expected in the vegetational cover. There is no evidence of erosion. A good site for a dam was mapped near the south boundary of the section.

TABLE 7.—PAGE 2, FIELD DATA SHEET.

PLANT SPECIES

Ada X	Dca X	Ppa	Cag	Ala X	ANu X	HRi X	Rve	Smi X
Apa	Dst	Ppr	CEl X	Ami X	Cin	Iax	Sho	Sse
ASm X	Fid	Pse X	Cfi X	Aca X	Cal	Lpu	Spe	
Ahi X	Fsc	PNw	Che	Afr X	Cpe X	Ljw	Sdi	
BSy	Hju	Sgr	Eac	Agn X	Dbi	Nvi	Sin	
Bgr X	Ker X	Scr	Epa X	Apa X	Eco	Ofr	Sde X	
Bin	Msg X	Sco X	Jat	Aca X	Ela X	Opo X	Sal	
Cca	Ppr	Svi X	Sam	Aer X	Gco	Pse	Sco	
Cmo X	PCa		Sva	Aex	Gle	Pla	Sca	
Clo	Pin			Alae	Gdi X	PHo X	Sdu	

SAMPLE DATA

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Av.	Total
Blue																						
gramagrass			2	1							1	2		1		1		1	2		5·5	
Common																						
speargrass							1									1					1·0	
Bluejoint		1											1				1				1·5	
Junegrass						1				1					1						1·5	
Sandberg's																						
bluegrass							1	1												1	1·5	
Sun-loving																						
sedge	1								1									1			1·5	12 5
Pasture sage						1									1						1·0	
Goldenrod					1																0·5	1·5
Little																						
clubmoss			2	1	3				2	4		2				1		1	3	1	10·0	10·0

RESULTS OF INVESTIGATIONS

In presenting the results obtained in the different pastures surveyed, data are given concerning 12 typical pastures, all of which are located on plate 2. Four are representative of short-grass prairie, four of mixed prairie, and an equal number of submontane mixed prairie. The material presented deals with the vegetational cover, the yield and carrying capacity, and with the yield of forage expressed in terms of animal products.

Short-Grass Prairie

The vegetational cover, yield and carrying capacity of four stations in the short-grass prairie are presented in table 8. These are typical examples of the conditions which exist within the type. Stations 2 and 3 are representative of average conditions over most of the area dominated by the short-grass association. Station 1 is an example of where conditions favour the growth of blue grama grass. Station 4 illustrates the type of cover found in the ecotone between the short-grass and mixed prairie.

As stated in the discussion on vegetation, and as indicated by the figures presented, blue grama grass is the dominant species in the short-grass region. Its usual cover ranges between 3 and 5 per cent, but covers of as low as 2 and as high as 10 per cent have been recorded. The other important grasses have much smaller ranges, although differences in their cover of 100 per cent are relatively common. The density of Sandberg's bluegrass shows a relationship to that of blue grama grass. It accounts for from 10 to 15 per cent of the grass cover at those stations which are typical of the association, but assumes a less important position in regions where growth factors are more favourable.

TABLE 8.—PERCENTAGE VEGETATIONAL COVER, YIELD AND CARRYING CAPACITY AT FOUR STATIONS IN THE SHORT-GRASS PRAIRIE

Plant Species	Station 1 L.I.D. No. 17 Community Pasture		Station 2 Val Marie A Community Pasture		Station 3 Many-berries, Alberta		Station 4 Newcombe Community Pasture	
	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre
	%	lb.	%	lb.	%	lb.	%	lb.
Blue grama grass	7·3	121	4·0	66	4·1	68	2·4	40
Sandberg's bluegrass	0·8	24	0·7	21	1·0	30	0·4	12
Common speargrass	1·3	65	1·1	55	0·7	35	1·9	95
Bluejoint	0·7	45	0·9	57	1·4	88	1·4	88
Junegrass	1·0	48	0·6	29	0·5	24	0·5	24
Short-awned porcupine grass			0·2	10			0·5	25
Northern wheatgrass							0·3	19
Alkali grass	0·1	2	0·1	2				
Sun-loving sedge	1·7		1·3		0·5		1·8	
Thread-leaved sedge	0·1	4	0·5	20				
Other grasses and sedges	0·5	12	0·4	6	0·4	6	0·9	14
Total grasses and sedges	13·5	321	9·8	266	8·6	251	10·1	317
Pasture sage	1·3		1·3		0·5		0·7	
Hoary sage bush	0·6	6	0·3	3	0·1	1		
Silver sage			0·1	8	0·1	8	0·1	8
Nuttall's atriplex					0·1	8		
Moss phlox	0·3		0·3		0·2		0·5	
Broomweed	0·1		0·1					
Other forbs and shrubs	0·7	3	0·6		0·4		0·3	7
Total forbs and shrubs	3·0	9	2·7	11	1·4	17	1·6	15
Total percentage cover and yield	16·5	330	12·5	277	10·0	268	11·7	332
Available forage 55% of total		182		152		147		183
Carrying capacity in acres per cow-month		3·6		4·4		4·5		3·6
Number of species listed	122		112		125		161	

There is usually a transitional zone between the mixed and short-grass prairies, where species of both associations are present. Sometimes this ecotone is many miles in width while in other cases it is relatively narrow. The first condition is well illustrated in the Val Marie Community Pasture, where Val Marie A is classified as short-grass and Val Marie B as mixed prairie. Between these two Stations, which are 12 miles apart, the vegetation exhibits characteristics of both types. Another illustration of a broad ecotone is Station 4, Newcombe Community Pasture, which is entirely within the transitional zone. Here the basal cover of blue grama grass exceeds that of any other species, but speargrass and bluejoint have covers of greater density than at other stations. Furthermore, porcupine grass and northern wheatgrass occupy positions of importance in the community. Depending on the species present and their relative importance, these transitional zones are classified as one or another of the major vegetational types.

The yield and carrying capacity of each station is shown in the column beside that for vegetational cover. The yield is stated in pounds of forage per acre and the carrying capacity in acres per cow month. It will be seen that most of the forage is produced by the few dominant grass species, and that, although the forbal cover often amounts to 20 per cent of the total, it provides less than 6 per cent of the forage.

Blue grama grass, although having the highest percentage basal cover of any species, does not produce proportionally. It often accounts for about one-half of the total cover, but seldom exceeds one-third of the total yield. At Station 1, where it occupies 54 per cent of the ground covered by grasses, it yields less than 38 per cent of the total. At Station 4, its cover is one-quarter of the total, but its yield is about one-eighth. This is an important matter, as one of the first phases in the trend of overgrazing is the disappearance of the taller and heavier-producing grasses. Although blue grama grass may replace these, it does not produce proportionally, and the carrying capacity is automatically reduced.

Pastures within the short-grass prairie region yield less than those within the other major vegetational types, the average range being from 225 to 325 pounds per acre. The most common yields obtained are close to those represented by Stations 2 and 3. The yields recorded for Stations 1 and 4 are high for the short grass association, but as indicated by the percentage grass cover higher yields can be expected at these sites. Although blue grama grass comprises about 50 per cent of the cover at Station 1, its greater abundance together with the yields of other species produces a higher yield than average. At Station 4, although the total cover is not much above the average, it is composed largely of heavier-producing species, consequently it yields considerably above the average for the type. The lowest yield secured to date was calculated to be 170 pounds per acre. This was secured on an eroded area where blue grama grass and plains muhly *Muhlenbergia cuspidata* (Torr.) Rydb. dominate the cover.

In addition to the data presented in table 6, each station has a dense cover of little clubmoss. This species often produces a cover that exceeds 50 per cent of the ground area, but ranges usually between 10 and 25 per cent. It is not considered to be a forage plant, as it grows too low for cattle to graze, although ranchers report that sheep eat it in early spring. However, its dense cover is very useful, as it helps to prevent wind and water erosion, and decreases damage by tramping. The density of this species is less in mixed prairie. It is seldom encountered in the submontane type.

Mixed Prairie

Information concerning the vegetational cover and yield at four stations in the mixed prairie is presented in table 9.

There are several co-dominant species in the mixed prairie association. These include the several listed in table 9, together with others which dominate particular communities. The data presented indicate that any two or more of these may be equally abundant. It is also shown that one or more of the taller-growing species may have a cover equal to or greater than that of the low growing blue grama grass. On this type blue grama grass has a much narrower range of cover than in the short-grass prairie, whereas the taller growing species exhibit greater fluctuations. Short-awned porcupine grass and northern wheatgrass which are seldom found in short-grass prairie are two of the dominant species in this association. Rough fescue is nearly always a constituent, growing in coulee bottoms, on northern slopes and at other sites where conditions favour its development. It may be either rare or abundant as indicated by its cover at Stations 6 and 8. Sandberg's bluegrass is sparse and often absent. In this association its cover seldom exceeds that of Station 7, and usually is comparable with that found at either Station 6 or 8.

A point worthy of note is the prevalence of pasture sage in the mixed prairie, where its cover is from two to three times greater than in the short-grass region. As the samples were all taken on normally utilized pastures, it is apparent that this species is relatively abundant in this association. As its presence is often used as an indicator of an overgrazed condition, cognizance should be taken of its natural position in the community before judgment is pronounced.

TABLE 9.—PERCENTAGE VEGETATIONAL COVER, YIELD AND CARRYING CAPACITY AT FOUR STATIONS IN THE MIXED PRAIRIE

Plant Species	Station 5 Monet Community Pasture		Station 6 Hillsburgh Community Pasture		Station 7 Val Marie B Community Pasture		Station 8 Compeer, Alberta	
	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre
	%	lb.	%	lb.	%	lb.	%	lb.
Blue grama grass	2·5	41	1·0	16	1·8	30	0·3	5
Sandberg's blue grass	.....	.....	0·1	3	0 5	15	0·1	3
Common speargrass	0·4	20	0·3	15	1·4	70	1·2	60
Bluejoint	2·9	182	2·4	147	0·7	45	0·2	12
Junegrass	1·4	65	1 0	48	0·9	44	0·5	24
Short-awned porcupine grass	2·3	115	1·8	90	1·9	95	1·1	55
Northern wheatgrass	0·1	6	1·0	61	0·2	12	1·8	115
Rough fescue	0·3	29	0 1	9	0·5	48	1·7	165
Awned wheatgrass	0·1	6	.....	.....	.....	.....	0 1	6
Wild oatgrass	0·1	2	.....	.....	.....	.....	0·1	2
Sun-loving sedge	2·0	.....	2·2	.....	1·5	.....	6·5	.....
Thread-leaved sedge	0·2	8	.....	.....	0·5	20	.....	.....
Other grasses and sedges	1 1	50	0·9	43	1·1	22	1·7	44
Total grasses and sedges	13·4	524	10·8	432	10·5	401	15·3	491
Pasture sage	1·9	.....	2·2	.....	1·6	.....	2·5	.....
Hoary sage bush	.....	.....	.....	.....	0·1	1	.....	.....
Silver sage	.....	.....	0·1	8	.....	.....	.....	.....
Nuttall's atriplex	0·1	8	0·1	8	.....	.....	.....	.....
Moss phlox	1·2	.....	0·5	.....	0·4	.....	.....	.....
Other forbs, shrubs and trees	0·8	5	0·5	2	1·2	11	1·1	9
Total forbs, shrubs and trees	4·0	13	3·4	18	3·3	12	3·6	9
Total percentage cover and yield	17·4	537	14·2	450	13·8	413	18 9	500
Available forage 55% of total	.....	295	.....	248	.....	227	.....	275
Carrying capacity in acres per cow month	.....	2·3	.....	2·8	.....	3·0	.....	2·4
Number of species listed	133	.....	177	.....	122	.....	125	.....

Station 8, Compeer, Alberta, is another example of a transitional type of vegetation, having characteristics of both the mixed and submontane mixed prairies. There is, however, a fair representation of short-grass species which are absent in typical submontane types. There is also a higher cover of pasture sage. Consequently, its vegetational cover is classified as mixed prairie.

Speargrasses and wheatgrasses produce most of the forage in the mixed prairie. This is well illustrated by the yields presented in table 9, where, except in transitional zones, species of these genera produce from 60 to 75 per cent of the forage. Blue grama grass which is usually a co-dominant in regard to basal cover provides less than 10 per cent of the yield. Yields listed under "Other Grasses and Sedges" are contributed largely by three members of the sedge family, awned sedge, beaked sedge and spike rush.

Mixed prairie yields more heavily than short-grass prairie. This difference is attributed to the heavier-yielding species which constitute the cover and to slightly greater basal coverage. Average yields range between 350 and 500 pounds of dry matter per acre. However, there is greater variability than in the short-grass association, since yields as low as 200 pounds and as high as 760 pounds per acre have been recorded, the first from a sandy area, the second on heavy clay soil. This great variability is to be expected, because the factors which determine the development of the association, particularly soil quality, vary exceedingly, and the different growth conditions are expressed in the vegetational cover and yield.

Submontane Mixed Prairie

The stations selected in the submontane mixed prairie are representative of four phases of the association. Station 9 is representative of the latitudinal aspect, while Station 10 exhibits the characteristics of a phase found at medium altitudes. The vegetational cover at Station 11 is representative of the phase found growing immediately below the pine forest. Station 12 typifies an intermediate type, where the soil is of fair quality and the topography moderately rolling. Certain data gathered at these stations are presented in table 10.

Dominance of rough fescue characterizes the submontane mixed prairie, accounting for from 17 to 50 per cent of the grass cover at the stations studied. Its abundance varies with soil and topography, being more prevalent in level areas than in those which are steeply rolling, and having higher covers on loam and clay loam than on sandy soils. The effects of these influencing factors are shown by the percentage stands of rough fescue at the four stations presented in table 10. Stations 9 and 10 are relatively level and have loam and clay loam surface soils, whereas Stations 11 and 12 are from moderately to steeply rolling, and their surface soils are classified as sand and sandy loam. At Stations 9 and 10 the cover of rough fescue is twice as great as it is at Stations 11 and 12.

The oatgrasses add to the cover. Within the confines of the submontane mixed prairie they are more abundant at higher altitudes. In the Foothills, Parry's oatgrass is the most common species of this genus, often accounting for 20 per cent of the vegetational cover. It has not been collected elsewhere within the region covered by the survey. Species of this genus with a general distribution are, wild oatgrass, California oatgrass, *Danthonia californica* var. *americana* (Scribn.) Hitchc., and one-spike oatgrass *D. unispicata* Munro.

Wheatgrasses, which include bluejoint, awned wheatgrass, northern wheatgrass as well as others of less abundance, are also important producers of forage in the submontane type. They account for from 5 to 19 per cent of the cover.

TABLE 10.—PERCENTAGE VEGETATIONAL COVER, YIELD AND CARRYING CAPACITY AT FOUR STATIONS IN THE SUBMONTANE MIXED PRAIRIE

Plant Species	Station 9 Wolverine Community Pasture		Station 10 Cochrane, Alberta		Station 11 Cochrane, Alberta		Station 12 Turner Valley, Alberta	
	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre	Vegetational Cover	Yield per acre
	%	lb.	%	lb.	%	lb.	%	lb.
Bluejoint	0·2	13	0·7	45	0·4	26	0·4	26
Junegrass	0·5	24	1·2	58	1·2	58	2·0	97
Short-awned porcupine grass	0·4	20	0·4	20	0·4	20	0·4	20
Northern wheatgrass	0·2	13	0·6	38	0·4	26	0·8	51
Rough fescue	4·8	466	5·6	543	2·0	194	2·5	242
Awned wheatgrass	0·1	6	0·9	58	0·2	13	0·9	58
Wild oatgrass	0·1	2	.....	.....	.....	.....	.....	.....
Parry's oatgrass	.....	.....	3·0	150	1·2	60	2·0	100
Sun-loving sedge	1·5	.....	2·2	.....	1·2	.....	1·3	.....
Other grasses and sedges	2·0	25	1·2	20	2·4	139	4·2	210
Total grasses and sedges	9·8	569	15·8	932	9·4	536	14·5	804
Pasture sage	0·3	.....	0·8	.....	0·6	.....	.....	.....
Roses	.....	.....	0·1	2	0·2	4	1·1	22
Shrubby cinquefoil	.....	.....	0·3	.....	0·5	.....	0·4	.....
Other forbs, shrubs and trees	2·6	16	1·6	28	2·5	46	2·6	18
Total forbs, shrubs and trees	2 9	16	2·8	30	3·8	50	4·1	40
Total percentage cover and yield	12·7	585	18·6	962	13·2	586	18·6	844
Available forage 55% of total	.....	321	.....	529	.....	322	.....	464
Carrying capacity in acres per cow-month	.....	2·1	.....	1·25	.....	2·1	.....	1·45
Number of species listed	120	.....	190	.....	193	.....	175	.....

Only two of the dominant grass species of the short-grass prairie are common in the submontane mixed prairie. These are bluejoint and Junegrass. Bluejoint occupies a much less important position in the submontane prairie than in the other types, whereas Junegrass increases in abundance being twice as common in the submontane as in the short-grass region. The sample data indicate that blue grama grass, speargrass and Sandberg's bluegrass are not constituents of the cover at the stations studied.

Shrubs and trees are important constituents of this association. Shrubby cinquefoil is nearly always present and may be either rare or abundant. It is more plentiful in the Foothills and Cypress Hills than in other areas where this vegetational type characterizes the cover. Pasture sage is found growing naturally on southern slopes, but is not a natural constituent on other exposures. It spreads rapidly when this type of prairie is overgrazed. At Station 9 the cover of "Other herbs, shrubs and trees," is composed largely of small cudweed *Antennaria microphylla* Rydb. At the other stations willows and American hedysarum provide most of the cover in this group.

The highest and lowest yields recorded to date on submontane mixed prairie are 1,500 and 345 pounds per acre respectively. It is seldom, however, that yields as high or as low as these are secured, the usual range being between 900 and 500 pounds. The average yield of all stations studied is approximately 700 pounds per acre.

The yield at each station varies according to the influence of physical and climatic factors. This is illustrated by the yields at Stations 10 and 11. These sites are only 15 miles apart yet their yields differ by 376 pounds per acre. The difference is attributed to poorer soil, rougher topography, a denser cover of unpalatable species and greater run-off at Station 11 than at Station 10.

The importance of sub-dominant species is indicated by the difference in the yields at Stations 9 and 10. At Station 10 the dominant grass, rough fescue, yielded 543 pounds and all grasses yielded 937 pounds per acre. At Station 9 the dominant species, also rough fescue, produced 466 pounds out of a total grass yield of 569 pounds per acre. Thus rough fescue yielded only 77 pounds more at Station 10 than at Station 9, but the difference between the total yield of grass amounted to 363 pounds per acre. Consequently grass species, other than the dominant, produced some 286 pounds per acre more at Station 10 than at Station 9. This difference is due largely to the greater abundance of sub-dominants of Station 10 than at Station 9, particularly, wheatgrasses, oatgrasses and Junegrass.

Yields given under "Other grasses and sedges" are produced by many species. At Stations 9 and 10 species of *Carex* produce most of the yield. At Station 11 species of the genera *Poa, Elymus* and *Carex* are the principal contributors. The high yield at Station 12 is produced by the same species together with awnless brome, the operator at this station having seeded a considerable acreage to this grass.

Comparative Yields and Carrying Capacity

In order that the yield and carrying capacity of the three major grassland types might be readily compared, the data involved are presented in table 11. These data were secured in studies conducted on 65 pasture areas. Of this number 21 are short-grass types, 33 are from the mixed prairie region and 11 are representative of the submontane mixed prairie. The figures presented under "Average" yield and capacity are the means of the yield and carrying capacity for all of these stations within each vegetational type. The figures presented under "Highest" and "Lowest" yield and capacity are those obtained on individual pastures or ranches, the best and the poorest which have been surveyed. Comparative yields are shown under "Average Yield Ratio", the average yield of the mixed and submontane mixed prairies being expressed as a ratio of the average yield of the short-grass prairie.

TABLE 11.—AVERAGE YIELD AND CARRYING CAPACITY OF THE THREE MAJOR VEGETATIONAL TYPES

Major Vegetational Types	Yield in pounds per acre			Carrying Capacity in acres per cow-month			Average Yield Ratio
	Highest	Average	Lowest	Highest	Average	Lowest	
	lb.	lb.	lb.	acres	acres	acres	
Short-grass Prairie	332	265	170	3·6	4·7	8	1
Mixed Prairie .. .	760	427	200	1·8	2·8	6	1 61
Submontane Mixed Prairie	1,500	705	345	0·8	1·7	3·5	2·66

Yields of Forage Expressed in Terms of Animal Products

The stockman is concerned with securing the maximum production of animal products, and with the maintenance of his pastures in a productive condition. Naturally there is a relationship between the yield of forage and the amount of animal products obtained from a unit area. However, this relationship is not constant, but varies according to the influence of several factors. Some of these are, the nutritional value of the vegetation, the season at which the vegetation is grazed, the class of live stock using the pasture, the distribution and quality of the water provided for the live stock, the methods of grazing practised together with others of equal or less importance.

During the surveys conducted, studies were made of the relation between the amount of herbage produced and the gains made by beef cattle on native grass pastures. These studies indicate that from 22 to 31 pounds of forage (dry weight) must be available to produce each pound of gain in flesh, and at the same time allow for sufficient carryover of pasturage, the average amount of forage necessary for these purposes being approximately 25 pounds. Since only about 55 per cent of the forage produced should be utilized in order that sufficient carryover be allowed for, the amount of herbage actually consumed to make a gain of one pound of flesh ranges between 12·1 and 17·2, and averages about 13·8 pounds. This applies to the grazing of typical native grass pastures by good quality beef cattle during the months of April to October inclusive.

A comparison of yields of forage and pounds of beef per acre obtained in 12 pastures is presented in table 12.

TABLE 12—EXPECTED AVERAGE YIELDS OF FORAGE AND BEEF AT TWELVE SELECTED STATIONS

Vegetational Associations and Stations Included in This Study	Expected Yields per acre	
	Forage lb.	Beef lb.
Short Grass Prairie—		
L.I.D. No. 17 Community Pasture	330	13·2
Val Marie "A" Community Pasture	277	11·1
Manyberries, Alberta	266	10·6
Newcombe Community Pasture	332	13·2
Mixed Prairie—		
Monet Community Pasture	535	21 4
Hillsburgh Community Pasture	446	17·8
Val Marie "B" Community Pasture	401	16·0
Compeer, Alberta	500	20·0
Submontane Mixed Prairie—		
Wolverine Community Pasture	585	23·4
Cochrane No. 1, Alberta	962	38·5
Cochrane No. 2, Alberta	586	23·4
Turner Valley, Alberta	844	33·8

These data indicate the gains that may be expected on pastures of different productivity in the principal grassland associations. The figures presented are based chiefly on actual gains made by two-year-old beef steers on native grass pastures. It will be noticed that the expected yields vary greatly, although less in the short-grass prairie than in either of the other principal types. There is also a considerable difference in the expected gains between each type, the average for the four pastures in the short-grass prairie being 12 pounds per acre, in the mixed prairie about 19 pounds per acre, and in the submontane mixed prairie approximately 30 pounds per acre.

SUMMARY AND CONCLUSIONS

A survey of the grasslands in southern Alberta, Saskatchewan and Manitoba was commenced in 1937. The purposes of this survey are to determine the botanical composition of the native grass pastures, to estimate their carrying capacity and to determine how they can be utilized to the greatest advantage. To date, surveys have been conducted on some three million acres of land located largely in community pastures and on individual ranches. This bulletin presents certain information relative to the types of grassland found within the region, with methods employed in the study of the vegetational cover and in the calculation of carrying capacity, and with some of the results obtained. These are summarized as follows:

1. There are three extensive grassland types used for grazing purposes within the area covered by the survey, namely, the short-grass prairie, the mixed prairie and the submontane mixed prairie.
2. Vegetational covers are secured by sampling with the point method. The results obtained are used to classify the vegetation and to calculate carrying capacity.
3. Intensity of sampling is an inverse function of the grass cover. Sparse covers require more sampling than those which are dense. Sampling is considered to be sufficient when the standard error of the mean is reduced to less than 5 per cent of the mean.
4. Carrying capacity is estimated by the point-yield method.
5. The yield of forage in any of the major vegetational types, differs from the yields of either of the other associations. Yields taken on short-grass prairie usually range between 225 and 325 pounds per acre. In the mixed prairie region the usual range is from 350 to 500 pounds per acre, while submontane mixed prairie usually yields from 500 to 900 pounds per acre. However, both higher and lower yields are obtained in all types.
6. Average carrying capacities of the three principal grassland associations vary according to their forage yields. In the short-grass prairie region the average grazing capacity is approximately 4·7 acres per cow-month. In the mixed prairie area it is about 2·8 acres per cow-month. On submontane mixed prairie it has been estimated at approximately 1·7 acres per cow-month.
7. All grasslands surveyed are classified according to the vegetational cover and according to the expected yield of forage.
8. A study was made of the relationship between yields of forage and gains made by live stock on native grass pastures. This study indicates that approximately 25 pounds of forage must be available to make a gain of one pound of beef and to leave sufficient growth as carryover.
9. There is a wide range of productivity in any vegetational type, consequently carrying capacity classifications based on large vegetational units are not satisfactory. These differences both large and small can be shown only by analysing the vegetational cover or by grazing trials. Because of its accuracy and relative rapidity the vegetational analysis offers the best means of determining the productivity of native grasslands.

ACKNOWLEDGEMENTS

The authors are indebted to Mr. L. B. Thomson, Superintendent of the Dominion Experimental Station, Swift Current, Sask., and formerly Superintendent of the Range Station, Manyberries, Alberta, for criticisms of the manuscript and for suggestions offered. They are also indebted to E. W. Tisdale and N. A. Skoglund for their contribution to the work at the Manyberries Range Station, which was basic to the work of the survey. Acknowledgements are made to W. R. Hanson, D. E. Lewis and R. Coupland for their assistance during field surveys.

LITERATURE CITED

1. Clarke, S. E. Pasture Investigations on the Shortgrass Plains of Alberta and Saskatchewan. Sci. Agric., 10: 732-749. 1930.
2. Clarke, S. E., J. A. Campbell, and W. Shevkenek. The Identification of Native and Naturalized Grasses by Their Vegetative Characters. Dominion of Canada. Department of Agriculture. Technical Bulletin. In press.
3. Clarke, S.E., and E. W. Tisdale. Range Pasture Studies in Alberta and Saskatchewan. Herbage Review, 4: 51-64. 1936.
4. Clarke, S. E., E. W. Tisdale, and N. A. Skoglund. The Effects of Climate and Grazing Practices on Short-grass Prairie Vegetation in Southern Alberta and Southwestern Saskatchewan. Dominion of Canada. Department of Agriculture. Technical Bulletin. In press.
5. Clements, F. E., E. S. Clements, F. L. Long, and E. V. Martin. Ecology. Carnegie Institution of Washington Yearbook, 38: 134-140. 1939.
6. Dominion Range Experiment Station, Manyberries, Alberta. Results of Experiments, 1927-1936 inclusive. Dominion of Canada. Department of Agriculture. 1937.
7. Fraps, G. S. The Principles of Agricultural Chemistry. The Chemical Publishing Co., Easton, Pa. 1919.
8. Levy, E. B. Strain Testing and Building. Herbage Publication Series. Bulletin No. 11. Aberystwyth. 1933.
9. Levy, E. B. and E. A. Madden. The Point Method of Pasture Analysis. New Zealand Journal of Agriculture. 46: 267-279. 1933.
10. Lewis, F. J., E. S. Dowding, and E. H. Moss. The Vegetation of Alberta. Journal of Ecology. XVI: No. 1, 19-70. 1928.
11. Morrison, F. B. Feeds and Feeding. Edition 20. Morrison Publishing Company. Ithaca, New York.
12. University of Saskatchewan, College of Agriculture. Reconnaissance Soil Survey of Saskatchewan. Soil Survey Report No. 10. 1936.
13. Snedecor, G. W. Statistical Methods. Collegiate Press, Inc., Ames, Iowa. 1938.
14. Thomson, L. B. Feeds for Wintering Cattle in the Dry Area. Dominion Range Experiment Station, Manyberries, Alberta. Mimeographed Report. 1933.
15. United States Department of Agriculture. Soil Conservation Service, Region Nine. Range Management Handbook. Rapid City, South Dakota. 1938.
16. Weaver, J. E., and F. E. Clements. Plant Ecology. McGraw-Hill Book Company Inc. New York and London. 1938.